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Malaria-Control in Malaya and Assam

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A Visit of Inspection, 1926-7

By

SIR RONALD ROSS, K.C.B., K.C.M.G., F.R.S.

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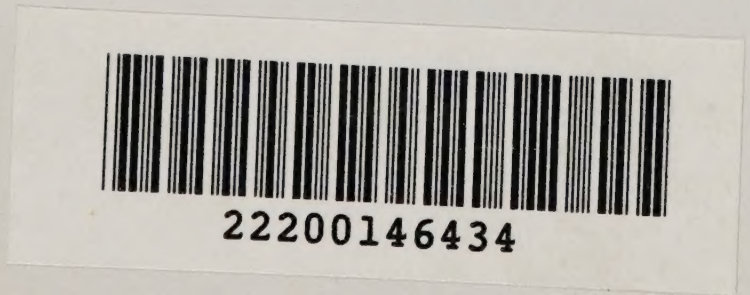
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MALARIA-CONTROL IN MALAYA AND ASSAM

A visit of Inspection, 1926-7

By Sir RONALD ROSS, K.C.B., K.C.M.G., F.R.S.

Director-in-Chief, Ross Institute and Hospital for Tropical Diseases, Putney Heath, London, S.W. 15.

I. PREFACE AND ACKNOWLEDGMENTS.

Shortly after the opening of the Ross Institute and Hospital for Tropical Diseases by His Royal Highness the Prince of Wales on the 15th July 1926, it was suggested that I should pay a long-deferred visit to Malaya and India in order to inspect the progress of anti-malarial operations in parts of those countries. For some years past, Sir Malcolm Watson had wished me to see operations in Malaya; and, more recently, Colonel J. W. D. Megaw, C.I.E., I.M.S., head of the Calcutta School of Tropical Medicine, had desired me to be present at the inauguration of a Gate of Commemoration at my old laboratory in Calcutta early in the present year, and it was thought that both suggestions could be accepted together.

Accordingly, Sir Charles McLeod, Bart., Chairman of the Ross Institute, kindly interested himself in organising the visit; and the general expenses were handsomely subscribed by the Indian Tea Association (London), 21, Mincing Lane, E.C.3, in 1926. The special expenses of the tour through Malaya were generously defrayed by Sir Malcolm Watson, who accompanied me the whole way and motored me through some 600 miles of the country; and the expenses of the subsequent tour through Assam were met by the Calcutta School of Tropical Medicine and by Dr. C. Strickland of that school, who organised the tour and went with me through a distance of 1,865 miles by rail, road and river—free passages being often granted to us by the railway and river companies concerned. My whole journey from London and back extended to about 20,000 miles.

I received the greatest kindness and the warmest hospitality from everyone from Singapore to Penang, Burma, Calcutta, and Assam [*vide* attached Itinerary]; and my thanks for valuable assistance frequently

rendered are especially due to Sir Malcolm Watson, D.Sc., M.D., and to Lady Watson; to Colonel J. W. D. Megaw, C.I.E., and to Mrs. Megaw; to Professor C. Strickland, M.A., B.C., and to Mrs. Strickland; and to Dr. C. A. Bentley, M.B., D.P.H., and to Mrs. Bentley. I am also much obliged to Major H. Lockwood Stevens, Secretary of the Ross Institute, for help rendered.

On the 25th March, after my return to England, I gave an informal address to the Indian Tea Association (London), at 21, Mincing Lane, E.C.3, regarding my movements and my conclusions, and thanked them for their valuable help.

I much regret that time did not allow me to study all the interesting matters in connection with malaria-control in Bengal, especially some of the more difficult problems with which Dr. C. A. Bentley, head of the Bengal Public Health Service, has to deal; but I judged that my services belonged chiefly to the planters who had been so good as to provide most of the funds for my journey; and hope that I may still be able to inspect the work done for the civil population at some future date.

1*st May*, 1927.

II. NOTES ON MALARIA FOR LAY READERS.

Malarial Fever is perhaps the most important of diseases from the economic point of view, because it haunts almost all warm countries, especially the most fertile rural areas, where it affects millions of people, including children, travellers, planters, traders, officials, and troops; causes probably one or two million deaths every year besides an immense amount of persistent sickness, and is almost constantly present at certain seasons of every year. Efforts to control it are therefore of the utmost importance to the human race.

The disease was well known to the ancient Greeks and Romans, who rightly connected it more or less with marshy or stagnant water. About 1640, cinchona bark (from which quinine is now made) was introduced into Europe, and was found to cure or at least to mitigate the disease if properly given. In 1880, Dr. A. Laveran discovered that the malady is produced by hundreds of millions of minute animal parasites (not bacteria) which live in the blood and multiply simultaneously, as a rule, just before each attack of fever. A few years later, C. Golgi and other Italian savants worked out the development of these parasites (called PLASMODIUM) in the blood, and showed that they belong to three different species which respectively cause the three well-known types of malaria, the quartan, the tertian, and the so-called malignant fever. Many hundreds of books and papers have now been written on these organisms and their effects.

In 1883-4, A. F. A. King, A. Laveran, and R. Koch, suggested that the malarial infection may be carried by mosquitoes, which so often breed in marshy or stagnant water. In 1894, the late Sir Patrick Manson added a very strong argument to this hypothesis. Next year I took up the study of the subject in India, always in close communication with Manson in England. After more than two years' constant failures with the common domestic mosquitoes called Culicines, on the 20th August, 1897, I succeeded in growing one of the PLASMODIA of men experimentally in a mosquito of the genus ANOPHELES in Secunderabad, but was interrupted for five months shortly afterwards. Next year I worked out the whole life-cycle of this group of parasites in the case of another PLASMODIUM, this time of birds, in CULEX FATIGANS mosquitoes in Calcutta, and showed that these mosquitoes when infected from feeding on infected birds will carry the same infection into healthy birds which they subsequently bite—and I actually infected numbers of healthy birds in this way. This work showed by analogy exactly how malaria enters human beings; but I was again interrupted in August, 1898; and three months later certain Italian scientists, especially A. Bignami, were able to extend my results (with full knowledge of my previous researches and technique) to the cases of the human PLASMODIA in Italy,

which they showed to be carried by Italian ANOPHELES. In 1899, however, H. E. Annett, E. E. Austen, and myself demonstrated the same thing for Sierra Leone; and since then the story has been repeated in almost all the warm countries of the globe, often with many refinements, and has been published in some hundreds more of papers—*vide* my PREVENTION OF MALARIA, 1911, and my MEMOIRS, 1923 (both published by J. Murray, 50a, Albemarle Street, London, W.1).

The result has been—so far as we know at present—that the malaria-parasites of men are proved capable of living only in ANOPHELES mosquitoes. They start growing in the thickness of the insect's stomach-wall and there produce spores (young ones) which work their way into the insect's salivary glands. These glands produce the irritating poison which is injected into our skin, and the spores enter the human blood with this poison—so that an ANOPHELES first picks up the PLASMODIA from a human patient, then allows them to grow inside her body for a week, and lastly infects one or more healthy persons by her bite. The story is exactly the same as that of birds' malaria; and the parasites alternate between man and ANOPHELES mosquito or bird and CULEX mosquito. How this process began it is difficult to say; but a similar process is very common in many parasites of higher orders living in other " hosts "; and we have no evidence to show, and no reason for thinking, that malaria is carried in any other way. On the other hand, indeed, malaria has often disappeared entirely after the carrying mosquitoes have been reduced in or banished from a specific area—a thing which would not have occurred if the malarial germs simply rise from the soil, as was previously thought.

A sceptic may now ask " How can we be so sure that malaria is carried only by ANOPHELES mosquitoes? " Very simply, by feeding numbers of mosquitoes of different kinds on a suitable case of malaria and then by dissecting and examining each insect after some days, when the characteristic malarial germs as originally described by me in 1898 will be found only in the ANOPHELES. This has been done repeatedly and in many countries during the last thirty years, always with the same result. Another, but a much more laborious way, is to show that new malarial infections occur only in places and seasons where and when ANOPHELES are present. Yet another argument is that ANOPHELES breed in just those natural waters, such as streamlets, marshes, and pools, which have long been recognised as causing malaria, while the common Culicines breed copiously in tubs, pots, cisterns, etc., round houses which are not malarious. Recently it has been found that artificial infection with malaria is often of great benefit to persons suffering from the otherwise incurable and fatal disease called " general paralysis," and ANOPHELES are now being frequently used to convey this curative malaria—and thus to make many additions to our knowledge as well

In 1895-9, when I worked in India, almost nothing was known about Indian mosquitoes. Now many volumes and scientific papers on mosquitoes

have been published in many languages by many expert entomologists who have described and classified the insects and have studied their habits and habitats minutely. We now know the prevalent species almost everywhere; how to breed, feed, and keep them; and how to infect them with malaria or yellow fever (which is carried by a Culicine mosquito) if required. There are now even special experts on these subjects called " malariologists "—unfortunately they are not numerous enough yet, but they will doubtless become so when their value is more generally recognised.

Of course, everyone knows that the larvæ and pupæ of mosquitoes exist only in water and hatch out in a week or more into the winged adults, which can then live for a month or sometimes much longer. Only the females suck blood from men or animals, in order to nourish their own eggs. Many hundreds of species are already known—in England they are usually called " gnats." Each species generally likes its own particular collections of water to breed in—tubs, pots, broken bottles, gutters, drains, cisterns, wells, rot-holes in trees, rain-water in palms and other plants; but the ANOPHELES prefer water on the ground—pools, puddles, ditches, hoof-holes in mire, edges of ponds and rivers, marshes, slush under grass, pools on rocks (even those left by tides), rice-fields, beds of rocky streams, drying water-courses, and even eddies in swiftly-running torrents, and sometimes wells and cisterns. The adults also have their favourite feeding places at night and their resting spots during the day—out-houses, byres, old wells, pits, huts, native houses, roofs, eaves, cupboards, the walls and roofs of rooms in well-built bungalows, and so on. The larvæ of the Culicines generally feed on particles at the bottom of vessels or remain suspended from the surface-film of the water by the breathing-tube at their tails with their head hanging downward; the larvæ of ANOPHELES generally float flat on the surface like little sticks and feed on particles which they find floating there. The adult Culicines generally have plain wings and sit on walls with their bodies hanging downwards and inclined to the wall; the adult ANOPHELES generally have spotted wings and sit on a wall with the tail pointed downward and outward at an angle away from the wall. These elementary facts should be familiar to all those who have to live in warm countries, because mosquitoes are not only unpleasant vermin but often very dangerous ones as well. To identify and name the many species of mosquitoes, however, as well as to study their exact breeding places and sometimes even to find them at all, usually require the services of an expert and the use of special books or pamphlets.

The question is often rightly asked, " How far can mosquitoes fly? " As they can fly as fast as a man walks they may be able to fly a hundred miles during their lifetime of a month or more; but as a matter of fact, like other animals, they tend to remain close to where they were hatched or born, as proved by the common observation that they abound most near their breeding or feeding places where such places are isolated. The distance to which they actually do travel must depend on several factors, especially

the local distribution of suitable breeding and feeding places. Many species seek shelter and sit close when a strong wind blows; others, it is said, may drift several miles. As a general rule we may be fairly confident that if they abound in or near a given house they are breeding somewhere close by. Anyway, the mosquitoes coming from a fixed pool must tend to become fewer and fewer in areas of the same size taken at greater successive distances from that pool—somewhat as rays of light and sound become fainter by spreading out with greater distance from their origin. The subject was studied mathematically by me in 1904, and subsequently by Professor Karl Pearson. It is said that if they cannot find food near by they may fly several miles to get it; but in alleged cases of this kind one always doubts whether the near-by ground has been adequately searched for their breeding places. On the other hand, if they *can* find feeding near by there is no reason why they should go further; and cases are on record where malaria carried by them abounded close to their breeding pools but did not occur even a few hundred yards away. Screens of jungle, of closely-planted trees, of low hills, and of intervening houses may keep them off—but do not always do so. Open country, warm weather and gentle winds should be most favourable for their flight. The golden rule is to seek for their larvæ first near at hand, and failing this to look further afield.

The seasons at which ANOPHELES mostly breed are warm seasons when there is sufficient surface-water suitable for their larvæ. Too much rain tends to scour out their breeding waters and also to diminish the adults, so that the beginning and the end of a rainy season are most suitable for them. In dry, cold weather they may apparently vanish almost entirely in places where they swarmed during the wet, warm weather—though even then a few surviving adults may be found hiding in damp places such as cellars and huts in order to start a new generation when the weather becomes favourable again. Of course, artificial collections of water and rivers and streams often complicate the picture; and as each species of ANOPHELES likes its own particular class of breeding-water it is not always easy to lay down fixed statements on such points about them. Everyone knows, however, that the adults tend to bite most readily in hot, still, damp weather; and we must remember that as they may live for weeks or months their numbers tend to accumulate towards the end of the mosquito season, that is, generally near the end of the warm rains. This is also generally the season when the largest number of new malaria-infections occur.

Not all species even of the genus ANOPHELES—and there are many—are able to carry human malaria. The point has been much studied during the last quarter of a century by three methods. The insects may be fed in captivity on suitable cases of malaria and be then examined microscopically for the parasites; or they may first be caught in the houses or bedrooms of cases of malaria; or it may be shown by laborious investigations that a given species of ANOPHELES has been associated with a given outbreak of malaria. All three methods are often employed simultaneously, and we now know

that the ANOPHELES may be divided into three groups with regard to their malaria-bearing capacity: a given species (1) may not carry malaria at all, (2) may carry in the laboratory and not in nature, and (3) may carry in both. Those of the third group are evidently the most important, but years of local observation are required to fix the blame adequately on a species. Even different strains of the same species seem to differ as to their malaria-bearing capacity; and the subject is continuing to receive close scientific attention.

Another question often asked is "How many ANOPHELES of known malaria-bearing capacity are required to produce an outbreak—few or many?" This point also has been studied mathematically by me and subsequently by Dr. Alfred J. Lotka in America. We have to remember the following facts. Only a few eggs of ANOPHELES succeed in hatching-out into adults; only a proportion of these adults ever succeed in biting men; again only a proportion of these succeed in biting suitably infected men; only a proportion of these become infected from the men; only a proportion of these live long enough (a week or more) to incubate the malaria-parasites fully in their bodies; only a proportion of these succeed in biting another man; only a proportion of the men so bitten become infected. The total result must be that only a very small proportion of the ANOPHELES hatched out in a locality can ever succeed in infecting a new case. In other words, new cases will not occur in a locality unless the number of ANOPHELES of definite malaria-bearing capacity in that locality is very large—except, perhaps, by some very exceptional bad luck in a few very exceptional cases. From such close reasoning (which can be easily put into mathematical form) we derive the very important practical conclusion that in order to control malaria we need not banish every ANOPHELES from a locality—we need only to reduce their numbers below a certain figure *per* man. This is just what has happened in England (and elsewhere) where malaria-bearing ANOPHELES still exist but have become so reduced in numbers that the chances are greatly against their carrying the malaria infection to new cases.* What the limiting proportion of ANOPHELES *per* man actually is cannot be calculated at present because all the data are not yet accurately known. The equations contain many variable factors each of which affects the final result, but they cannot be discussed here in detail.

The number of new cases of malaria must depend not only on the number of carrying ANOPHELES but on the number of old cases of malaria from which the ANOPHELES carry the parasites into the new cases, and not only on these but on the accessibility both of the old and the new cases to the insects. Hence we can employ three methods for controlling malaria, namely (1) mosquito-reduction, (2) cure of the old cases of malaria with quinine, and (3) exclusion of mosquitoes by means of nets and screens.

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* An outbreak actually did occur in England during the war, owing to the importation of malaria cases from Salonika; but it soon ceased.

Books may be, and have been, written on these three methods. Each is appropriate under certain conditions; two of them may be combined under other conditions; and sometimes all three may be used together, as when the Panama Canal was being made.

All three methods cost money. But before considering them at all we must remember what is frequently forgotten, what is, in fact, the fundamental economical consideration, that malarial fever itself costs a great deal of money. It cripples thousands or millions of people for months or years; it often impairs the whole labour force of a plantation or of a village or town just when the crops require the closest attention; it fills the hospitals (which are expensive institutions); it often demands treatment and maintenance allowances; and it generally doubles (at least) the death rate in localities in which it abounds. A planter in Ceylon told me that it cost him a thousand pounds a month during the malaria season on one of his plantations alone. It is often one of the most expensive items in the cost of military campaigns; and it has even caused the abandonment of whole villages and stations and of extensive areas of cultivation. We must always remember these facts when we talk of the cost of malaria prevention. Both malaria and malaria-control cost money; but the former costs health and even life itself in addition.

Local conditions often vary so much, even a few hundred yards apart, as to the breeding waters of the ANOPHELES, the species concerned, their respective habits and carrying capacities, the accessibility of human habitations, and the best methods of dealing with particular waters, that it is quite impossible to give any brief account of the great anti malarial measure of mosquito-control, which is obviously the best measure where practicable. The work required for it is divisible into two classes—temporary and permanent work. In temporary work, breeding waters are treated with oil, or with Paris Green, or other chemicals, or even by introducing small fish to eat the larvæ, or by removing surface-water-weeds or grass which shelter the larvæ from fish, or by straightening the banks of small streams, and so on. Permanent works, such as draining marshes, rectifying the banks of lakes, rivers and streams, draining ravines (in which some of the worst ANOPHELES live), cutting down marshy jungles, excluding tidal waters, and many others, are generally much more expensive and require the assistance of engineers and often of specially trained engineers. The work can sometimes be done by an energetic manager alone, or with the help of a local medical officer; but in wet or water-logged areas it demands the preliminary surveys of a malariologist, whose advice will often save wastage of funds on dealing with harmless waters. In some cases also legislation may be required to control defaulting neighbours or villages. It is for the future to organise all such work so as to get the best results over a large tract of country for the least expenditure of money and time.

The second method of malaria-control is to treat all the old cases of the disease persistently with quinine until they have no PLASMODIA left in

them to be carried into the blood of others by the local ANOPHELES. This requires repeated examination of the blood of all persons in the locality by a medical man or other expert. It is not enough to judge merely by the symptoms, because many people, especially native children (who are most frequently infected), may contain swarms of the parasites and yet may show no symptoms at all for considerable periods. Then again, quinine must be given regularly for some time in order to have the desired effect, and many people, especially Indian coolies, object to taking it. The cost of the quinine and of the necessary medical attendance is likely to be great with large numbers of people. Nevertheless, the method has a double advantage—it cures the old cases besides preventing new ones; and it should be used as much as possible if only for the sake of those old cases, which otherwise tend to continue " relapsing " for month after month, even where there are no mosquitoes. At the end of the war, two whole divisions badly infected with malaria at Salonika were put into the front line in France, owing to the able quinine treatment given to them by Col. J. Dalrymple, R.A.M.C. (T.C.)—see Observations on Malaria (edited by me), War Office, December, 1919. An extension of the method consists in what is called general quinine prophylaxis—everyone has to take quinine as a preventive whether he is infected or not. It produced only temporary protection in Salonika and is troublesome and expensive, but has been much advocated by French medical men.

The third method of malaria-control, exclusion of mosquitoes by mechanical means, can be employed by everyone if he chooses. ANOPHELES feed almost entirely during the hours of darkness or twilight, and most persons are infected during sleep. The ordinary bed-net is perhaps the best precaution against malaria. The top as well as the four sides should be made of netting, not less than eighteen holes to the inch. If mosquitoes are numerous I advise that the net should be suspended *inside the poles* and tucked under the mattress; and in this case the lower part of the sides (not the top) should be made of long-cloth because the hands and feet of the sleeper may come into contact with the net just above the mattress and can then be easily bitten by outside mosquitoes through ordinary netting. The cost of a bed-net is trifling compared with that of a malarial infection. I myself have been infected with malaria only once in spite of sixteen years' service in India and thirteen subsequent " malaria expeditions " to warm climates; and I attribute this good fortune chiefly to my scrupulous use of the bed-net. If the net is drawn tight and the bed is close to a window there is very little impediment to the entry of air. Punkas or fans, inside or outside the nets, or by themselves, are now being largely employed. Without such precautions a person may be bitten by scores of mosquitoes during a single night, and if some of these are ANOPHELES he may be infected with malaria within a day or two of arrival in the tropics. It is astonishing how careless people are even when they possess nets—which may be left full of holes or hitched up anyhow against

the bedding. Well-to-do Indians now use nets much more generally, but often without proper hanging; and there is no reason why they should not be used by the poorest for themselves and for their families. It would be a " profitable charity " for planters' managers to make their coolies employ them. The Indian generally sleeps with a corner of his sheet over his head, but is probably bitten much nevertheless; and his children frequently become infected with malaria shortly after birth. Personally, I advise the use of a bed-net everywhere and for everyone in the tropics, at all seasons, and whether mosquitoes are to be seen or not.

Wire-gauze protection to houses, or at least to bedrooms, is now frequent in India, and should always be encouraged. Where a number of people sleep in the same room, as in hospitals, asylums, schools, work-houses, and in some workmen's dormitories or coolies' lines, it is absolutely imperative and should be made compulsory by law. In such cases, a single infected ANOPHELES may infect person after person within a few nights by wandering from one to another, because its salivary (or poison) gland may still contain hundreds of the malaria-spores after it has bitten several people. Under these circumstances the entry of an infected ANOPHELES is about as dangerous to the inmates as the entry of a tiger would be; and such a mosquito, finding herself in the presence of plenty of food, is likely to haunt her comfortable quarters for weeks or months, infecting or re-infecting everyone in the ward or dormitory. The sudden and widespread outbreaks of malaria among coolies are often to be explained by this " congregate sleeping "; and yet little attention is paid to the point, even now after a quarter of a century. The same danger exists with all families who sleep unprotected in the same room, and especially with Indian coolies and their wives and children who generally occupy the same little chamber indefinitely—the mud walls and bare bamboo-roofs often harbour numbers of mosquitoes for months, and there is no difficulty in seeing why such people are so " full of malaria." Possibly the same old female ANOPHELES become regular " man-eaters," like some tigers, while their relations live only on cattle or birds in the open. The same thing was found to occur in camps in Panama when I was there in 1904, and has doubtless been responsible for much of the malaria among troops on active service, and their followers, from time immemorial. In a hospital ward at Wilberforce, Sierra Leone, in 1899, we actually found malaria-parasites in a quarter of the patients present and at the same time in a quarter of the ANOPHELES caught in the ward! Unscreened hospitals are very often centres for malaria-infection. Dark go-downs and huts with smoke-begrimed walls and open rafters and roofs are frequently full of ANOPHELES which descend and bite the inmates every night. Much greater care should be taken, and is being taken, with the housing of officials, servants, coolies, and labour forces. Windows should be large, roofs ceiled with sheets of corrugated iron, and roofs and walls should be kept well painted white, or at least frequently whitewashed, so as to avoid the dark corners which mosquitoes love. The expense of building

proper " cooly lines " must be small compared with that of annual outbreaks of malaria (and other diseases); and the wretched native shanties which one still sees all over India, and even in the heart of Calcutta, ought to be suppressed by law. People often say that the Indians prefer to live in them, but I doubt it—too often they have no experience of anything better.

The lay reader will wish to know how we estimate the amount of malaria in a locality to justify us in saying that the disease is increasing or diminishing. The ideal way is for an expert to examine every person living within the area, excluding new-comers, for the symptoms of malaria, their history, their blood, their spleens, and their appearance. Where there is no time for this, " random samples " of the population are taken, the results being corrected for " statistical error." A rapid and yet very accurate measurement is derived merely from the " spleen-rates " of the children under twelve or fifteen years of age. In all malarious countries their spleens are frequently enlarged; and the enlargement can be felt or even seen so quickly that for a rough but useful estimate 100 children may be examined within an hour; and the spleen-rate is the ratio of the children with enlarged spleens to every hundred of them examined. The rate varies from 100 per cent. in very malarious places to zero in non-malarious ones; but it may be about 5 per cent. or more in healthy areas close to unhealthy ones, owing to importation of cases from outside; and it is usually from 30 per cent. to 60 per cent. in moderately malarious localities. The general death-rate of a country is a useful indication, because it is often double or more in a malarious colony or city what it is in a non-malarious one otherwise in the same condition—witness Mauritius and the Seychelles, for example. The general death-rate also shows a great rise during the malaria season, which is not to be found in the statistics of non-malarious countries. The malaria-admissions at hospitals constitute another test if other causes of variation in the figures are excluded. But, of course, all these methods of measurement require more or less expert knowledge. For a planter, perhaps the most reliable test of all is his annual loss of labour during the malaria season, not to mention its effects on his servants, his family, and himself!

The actual treatment of cases must be left to medical men; but the lay reader should understand that so long as patients continue to harbour malaria parasites at all they will be subject to relapses of fever, and may also infect other people if any of the carrying ANOPHELES can succeed in biting them.

III. NOTE ON MALARIA PREVENTION SINCE 1898.

My work of 1895-8 had been undertaken not in the interests of general science or of parasitology, but in order to save life and health by finding out exactly how malaria is acquired; and therefore before I left India, in February, 1899, I reported briefly to the Government of India on the practical possibility of controlling malaria in towns by reducing mosquitoes (method 1). The same thing was emphasised at much greater length in my inaugural lecture at Liverpool, and both report and lecture were published in July, 1899. At the end of that month, Austen, Annett and I departed for Sierra Leone (see page 6), where we studied the matter in detail, together with the habits of ANOPHELES, and we published three lengthy reports of our findings in the British Medical Journal (September and October), the Lancet, and at the University Press of Liverpool (February, 1900). About the same time that distinguished scientist, Robert Koch, who had fully confirmed my researches on the malaria of birds, published his suggestion for malaria-control by quinine (method 2). Little or nothing was however done in malarious countries to follow up any of our recommendations. At the end of 1900, the Americans proved that yellow fever is carried by STEGOMYIA mosquitoes, just as malaria is carried by ANOPHELES, and they started to control mosquitoes on a large scale in Havana, early in 1901. At the same time I obtained subscriptions for a similar attempt in West Africa against malaria, and started for Sierra Leone again on the 15th June, with Dr. Logan Taylor to assist me. Both attempts were very successful, but the former was an undertaking of the American Government, and the latter merely a private enterprise, which of course could not be continued indefinitely with only private funds. Taylor remained in West Africa till April, 1903, without much encouragement by the authorities. In September, 1902, came the " perfect proof " of malaria-control by means of mosquito-control, at Ismailia on the Suez Canal. Malaria had been present there for years and had reached the figure of 2,284 cases in 1900 out of about 7,000 inhabitants, and Sir William MacGregor, Governor of Lagos (himself a medical man keenly interested in the work), and myself, were invited by the Suez Canal Company to go there and advise. As there is practically no rainfall at Ismailia, it was a cheap, easy and quick matter to clear out nearly all the mosquitoes. The cases of malaria fell to 214 in 1903 and to zero in 1906. In 1903, the American Government began the construction of the Panama Canal, and did so very wisely by a large preliminary scheme of mosquito-control against both malaria and yellow fever, by making mosquito-proof houses and barracks, and by other measures. I visited the Canal zone in 1904 at the request of the authorities, and can testify to the excellence of their work, which led to the construction of the Canal at a very small cost of life among the workmen.

It would require another special book to describe and criticise all the numerous local malaria-control schemes which were commenced in those early years—In Italy and German possessions chiefly by quinine, and in others by various methods. In my book on the Prevention of Malaria, the first steps in many of these are outlined by twenty contributors, and I myself have made thirteen visits abroad for the same purpose from 1899 to 1927, while innumerable books and papers on the subject have been published by many other workers in many countries during that period.

The great work in Malaya, commenced in 1901, will be dealt with in the following pages.

IV. VISITS TO GIBRALTAR AND MALAYA.

I left London on the 29th October, 1926, and first spent a week at Gibraltar, where my friend Colonel W. Clayton Smales, D.S.O., R.A.M.C., Health Officer both for the troops and the municipality, was, I know, conducting a mosquito-control campaign. Very few ANOPHELES are ever seen on the Rock, though they abound at Algeciras and on the mainland, but various Culicines, especially AEDES ÆGYPTI, better known as STEGOMYIA FASCIATA, used to abound there and torment the inhabitants, and yellow fever and dengue carried by these insects have prevailed in the station in the past. Two years ago the municipality allotted a special fund for dealing with the pests, and assistance was also given by the military, the naval, and the colonial authorities. The task was one of no little difficulty because most of the houses have water-cisterns in the roof and also under the floor, while the poorer dwellings are full of washing-tubs which are kept full of water (to prevent shrinking) when not in use and thus become suitable for the common domestic mosquitoes. Anyone acquainted with public-health work knows the difficulty of persuading the poorer (and even the richer) classes to change their habits in the smallest degree for sanitary reasons; but Colonel Smales's campaign has evidently been successful in that crowded station, and I did not see a single mosquito where I lived, though it was the season when many Culicines enter houses for hibernation. The municipality gave me a reception (it has contributed very handsomely to the Ross Institute), and H.E. the Governor, General Sir Charles Monro, Bart,, a dinner; and I had a consultation with the Hon. Mr. Bowring, Chairman of the Municipality, and Colonel Smales, on the mosquito-control question. Colonel Smales's last report was published in the Annual Report on the Health of Gibraltar for 1925. Up to eighteen men were employed for the work, and the cost was about £600 for the year.

My visit to Malaya was undertaken on the invitation of Sir Malcolm Watson, to enable me to see what was being done there in the way of malaria-control—for the same purpose as my visit to Ceylon in 1926 (see pamphlet issued by the Ceylon Association, and by the Ross Institute for Tropical Diseases, London, 1926). The Malayan campaign has not been discussed yet because I have to devote a special section of this report to it. It was almost the first commenced and has been the most persistent, the widest, and the most successful of malaria-control campaigns in British areas—perhaps in the world. Of course I had heard much of it ever since 1901, but had never been able to see Malaya before. A full description of the work will be found in Watson's great book, The Prevention of Malaria in the Federated Malay States, a Record of Twenty Years' Progress (J. Murray, 2nd Ed., 1921, pp. 381, 36s.). The story is briefly as follows:—

In January, 1901 (just about the time that the Americans and myself were starting our campaigns in Cuba and West Africa respectively), Watson

was appointed Government Surgeon at Klang, in Selangor, one of the Federated Malay States, a town of 3,576 inhabitants and 293 houses, contained in an area of 290 acres, of which 22 acres were swamp and 85 acres jungle or dense growth. He found his hospital full of cases of malaria, and after careful consideration of the various methods of malaria-control decided on ANOPHELES-control. He mapped the breeding-waters and found them especially in a swamp in the middle of the town. In May, 1901, he proposed drainage of this swamp by the Klang Sanitary Board, and this was recommended and done next year. In the meantime, as he says, the whole population was demoralised by the malaria and the annual death-rate rose to the proportion of 300 deaths per thousand people; but the sanitary staff began at once to clear jungle, to do some minor drainage, and to insist upon owners of private property doing the same under local regulations. Gradually the town was drained, the actual cost for the five years 1901-1905 being 35,846 Malayan dollars, or about £4,182, besides expenditure on some " minor " work.

Klang is in hilly, inland country; but five miles nearer the coast there is the associated town of Port Swettenham at the mouth of the Klang river, built almost in the midst of reclaimed mangrove swamps; and it was opened for shipping on the 15th September, 1901. Immediately afterwards, as usual, an epidemic of malaria commenced—both the inhabitants and the crews of the ships were attacked in large numbers. In 27 native houses 78 out of 127 inhabitants and 25 of the houses were affected, and the High Commissioner ordered the temporary closure of the new port. On the 20th April, 1901, however, Watson had already forwarded a set of recommendations for reducing the disease there—clearing and levelling, filling abandoned drains, complete drainage, notification and hospital treatment of malaria cases, and experiments with mosquito-netting and quinine. These recommendations were approved by a commission which was subsequently appointed, and were put into force at a cost of 52,360 Malayan dollars, or about £6,109, in the five years 1901-1905.

As at Ismailia in 1902-3, the results were immediate in these two towns, and the epidemics rapidly passed away. The cases of malaria at the hospital from Klang and Port Swettenham fell from 610 in 1901 to 199, 69, 32 and 22 in the next four years, while, as a control observation, those from the surrounding untreated country rose from 197 in 1901 to 204, 150, 260 and 353 in the next four years. At the same time the total deaths (which as everyone knows are always much greater in malarious countries) fell in these two towns from 582 in 1901 to 144, 115, 122 and 113 in the next four years, while they rose in the surrounding country from 416 in 1901 to 403, 428, 490 and 622 in the next four years. No quinine was used all this time except for patients; and mosquito-nets were abandoned in the hospital.

Following these first successes anti-malaria work in Malaya has constantly increased in extent and efficiency during the last twenty-five years.

Watson soon extended his labours to neighbouring areas, especially to the numerous fine rubber and other plantations, and was speedily joined by many government and plantation doctors. In 1903-04, Dr. G. F. Leicester identified and described many of the ANOPHELES in his CULICIDÆ OF MALAYA, and it was soon seen that species has much to do with both the prevalence and the control of malaria. Among the many Malayan ANOPHELES, of the proved malaria carriers, A. UMBROSUS lives in the shade of jungles, A. LUDLOWI in mangrove swamps, A. LISTONI in running water, and A. MACULATUS even at the edges of fast running water. Copious if not exhaustive studies of these and other species have been made by Dr. C. Strickland, and some more by Drs. Stanton, Barbour, Hacker, and others—altogether much fine work. The important facts were soon discovered that if jungle is cut down in order to remove UMBROSUS, species that live in the open enter; that different species haunt the hilly country and the plains; that some rice-fields breed dangerous ANOPHELES, while others do not; that ravines full of jungle are often less malarious than when they are cleared; and so on. Methods of dealing with the many different problems were soon devised and many comparative estimates made of the respective values of the different methods of malaria-control (page 9). As a whole, ANOPHELES-control has been most favoured in Malaya.

In 1911, in consequence of an able report by Dr. W. R. C. Middleton, the Health Officer, Watson was invited to visit and advise regarding Singapore, the capital of the Straits Settlements, situated at the southern extremity of the Peninsula. His advice was taken and was followed by a rapid and permanent fall in the spleen-rate of children (page 13), and also by one of the general death-rate, which declined from an average rate of 42.33 in 1892-1911 to one of 34.78 in 1912-1919. Moreover, the great rises of general death-rates which occur (as well known) during annual malaria seasons in malarious countries began to diminish rapidly. From 1919 to 1925 inclusive, the annual death-rates have been 33.04, 33.20, 33.30, 31.26, 26.56, 26.49, 27.61. In some years epidemics of other diseases, especially influenza, have sent up the death-rates; but one cannot examine details here.

My ship arrived at Penang at 8 p.m. on Thursday, the 2nd December, and Sir Malcolm Watson kindly came on board in order to conduct me through the whole of my tour in Malaya. We arrived at Singapore on the 4th December at 2 p.m., and were met by the Hon. Dr. A. L. Hoops, Principal Medical Officer, by Dr. P. H. Hunter, the Medical Officer of Health, and many other officials, and went to stay at Government House with H.E. Sir Laurence Guillemard, the Governor, and inspected the fine new General Hospital the same evening, and dined with the Malayan Branch of the British Medical Association. Next day we inspected the anti-malaria work done within municipal limits, and on the following day the similar work being carried on at Gunong Pulai in anticipation of the large new water-supply for Singapore, of which the former spot among the hills is to be the

storage area—a very wise precaution in order to forestall the outbreak of malaria which would otherwise certainly occur among the large labour force required. On the 7th we examined the suburban rural anti-malaria measures with Dr. Hoops and Dr. J. W. Scharff, and I lectured on malaria to about 500 people at the Medical College in the evening. On the 8th we inspected the site of the new Naval Base, where Surgeon-Commander Given is already anticipating malaria among the workmen, as is being done at Gunong Pulai; and we took ship the same evening for Port Swettenham.

We received the kindest hospitality from everyone during our four days' stay at this great city of 400,000 inhabitants; and I was much impressed with the vigour and the extent of the malaria-control being exercised there. Dr. Hunter told me that he was employing over 400 men on the work within the town-area—and the cost was small compared with that which malaria would have otherwise inflicted on the city. No other city in the British Empire has, I believe, progressed so far in malaria-control as Singapore; and everyone I met was full of enthusiasm for it. Each step taken has been preceded by careful entomological as well as engineering surveys, and the problems have often presented considerable difficulties. The improvement is rapid and will be greater still in the future.

We arrived at Port Swettenham at 8 a.m. on Thursday, the 9th December, and inspected this scene of the early triumph of malaria-control. I stayed with Sir Malcolm and Lady Watson at their house near Klang, five miles from Port Swettenham, for eleven days, during which we inspected most points of interest in the neighbourhood—of which details will be found in Watson's book (page 16). Beginning with Klang itself, we next drove north to see rubber estates now improved or rendered healthy, including Kampong Kuantan, where the excess of subsoil water is extracted by pumping, and the Kapar Drainage Scheme, where 37 miles of main drains sufficient for 24,000 acres were constructed after 1904 at a cost of 110,000 Malayan dollars. Then we drove east on similar missions, and on the 13th viewed Kuala Lumpur, the beautiful capital, with its fine station, hotel and houses, its Government Laboratories, its Malaria Bureau, and especially its ravines between the hills, which were formerly the source of much malaria in the town but have now been dealt with by means of subsoil drainage pipes of earthenware (concrete proved perishable). Each ravine now consists of open grassy slopes leading down to a perfectly flat grassy lawn-like bottom, under which the subsoil drains at a depth of five feet carry off the ordinary seepage, exceptional storm-water flowing away freely over the flat grass surface of the bottom without being able to damage it. Dr. R. Dowden, the Principal Medical Officer, and a number of gentlemen entertained us to lunch. Next day we saw the station called Jugra, which had to be abandoned on account of malaria in 1917, and on the 15th went to Carey Island, near the mouth of the Klang River, further seaward from Port Swettenham. This was originally a mangrove swamp full of ANOPHELES LUDLOWI, one of the worst malaria carriers, and is now a

flourishing estate of 10,000 acres. The tidal river here has a 16-foot rise, which is easily dealt with simply by building sea-walls, deep drains, and sluice-gates which automatically let out the ebb-tides but exclude the rising tides. This work was commenced in 1907, and there are now comfortable bungalows on the island holding about thirty Europeans, and also a large labour force of over 2,000, with no indigenous malaria and a child's spleen-rate of only 1.6 per cent. in 1915. Malaria-control here has cost nothing at all, the drainage work being required for the planting in the first place. On the 18th we visited the Institute for Medical Research at Kuala Lumpur, under Dr. Fletcher, who is carrying on many valuable investigations, lunched with the Hon. Mr. W. Peel, the Chief Secretary, and Mrs. Peel, and were given a reception by the Hon. Mr. Choo Kia Peng.

Next day we left Klang for a tour by motor car northwards to Penang and successively visited Ipoh, Gopang, Batu Gajaha, Kuala Kangsar, Bukit Gantang Pass, Kaiping, Perak, and Penang, which we reached on the 23rd December, receiving the kindest hospitality everywhere on the journey. The large flat expanse of the Krian Irrigation paddy fields of 60,000 acres near Penang is of considerable interest because there is little or no malaria near them. This is by no means always the case with paddy fields elsewhere, especially in small valleys between hills or by the sides of running streams—though even these are sometimes healthy. Yet in the Krian paddy fields two species of "laboratory carriers" of ANOPHELES are common: we infer from the Krian statistics that they do not carry malaria naturally to any great extent. On the other hand, paddy fields between hills often swarm with A. MACULATUS, which lives in hill streams and is a very efficient malaria carrier in nature. As Watson has so well said, waters of the same type may vary greatly in their malarial potentialities, because each dangerous species of mosquito selects precisely the kind of breeding-water which, for unknown reasons, it prefers. Many studies are being made on such points. During the trip we took some spleen-rates and were able to observe several points of interest.

Next day (the 24th December), after a dinner and a lunch given to us by the medical men of Penang, I said farewell to Sir Malcolm Watson, who had so generously devoted both his time and his money for three weeks to render my visit to Malaya as instructive as possible; and I embarked for Calcutta the same evening.

I must mention (though I have no space to describe) two subjects of immense importance for malaria-control in Malaya, the formation of local and general Malaria Control Boards and Mosquito Destruction Boards, and the legislation required to give effect to their measures. Under these enactments (1) the Railway Department is responsible for Railway Reserves; (2) the Boards are responsible for Government Reserves and State Lands and for small holdings (less than 25 acres); and (3) owners are responsible for larger estates. I understand that we owe this important legislation to Sir George Maxwell, recently Chief Secretary, Kuala Lumpur. Both he and Sir Malcolm Watson are members of the Council of the Ross Institute.

V. VISITS TO RANGOON, CALCUTTA AND ASSAM.

The S.S. " Ellora " from Penang reached Rangoon on the 27th December and stayed there for four days before proceeding to Calcutta. There was no time to travel up country (the Governor, H.E. Sir Harcourt Butler, was in Mandalay and had invited me to stay with him), so that I accepted the very kind hospitality of Mr. B. Stephenson, Manager of the Imperial Bank of India at Rangoon, and took the opportunity of having talks on malaria-control in Burma with Colonel E. Bisset, I.M.S., P.M.O., and Major G. G. Jolly, I.M.S., Director of the School of Hygiene, there, There is little malaria in and near Rangoon, but I was consulted regarding the papers connected with several schemes up country, saw the Malaria Bureau, called on the Minister of Health, met several influential gentlemen in connection with malaria, received much kind hospitality, and re-embarked on the " Ellora " on the last day of the year.

We reached Calcutta at noon on the 3rd January, 1927, and I was met by Colonel J. W. D. Megaw, C.I.E., I.M.S., head of the Calcutta School of Tropical Medicine; Dr. C. Strickland, Professor of Entomology there; Dr. C. A. Bentley, head of the Bengal Public Health Service; and by a deputation from 1,087 Indian Anti-malaria Societies, headed by Rai Bahadur Dr. Gopal Chatterjee, who originated this useful movement. I stayed with Colonel and Mrs. Megaw, inspected the School, met many of the officers connected with malaria work, dined with H.E. the Governor of Bengal, the Earl of Lytton, and Countess Lytton, and on the 7th January was present when Lord Lytton unveiled the handsome Gate of Commemoration leading into the old laboratory connected with the Calcutta General Hospital, in which I worked in 1898 (page 5). The memorial is situated just opposite to the Queen Victoria Memorial on the Maidan, and was designed under the auspices of the School of Tropical Medicine. Many people were present, and I am naturally very grateful to all concerned for the great honour which they paid to me. A full account of the ceremony was printed in the Indian Medical Gazette (which published many of my original papers up to 1899) in March, 1927. On the 10th January I lectured on malaria to a large audience before Lord and Lady Lytton; and next day received a very pleasant ovation with a silver casket and a bag of 550 rupees for the Ross Institute from the Indian Anti-malaria Societies already mentioned, over 1,000 people being present.

The same evening, Dr. Strickland and I departed for a tour in the Duars, the Darjiling District (where I did much of my work in 1898), and Assam, under the auspices of the Indian Tea Association. Professor Strickland, who had formerly done such important work in Malaya, was

then and is now engaged on similar anti-malaria work for the numerous plantations in the districts visited by us, and has complete surveys of these areas in his office at Calcutta—so that he was able to organise our journeys in the most efficient manner possible and to show me as much as he could in the time available. Moreover, it was the season for the annual meetings of planters, so that I was able to address large numbers of them with a view to stimulating general anti-malaria work among them—and I hope that my visits may prove useful for this reason.

We began with Jalpaiguri in the Duars, where we met the planters' doctors to talk matters over, and where I then addressed the planters on Wednesday, the 12th January. Next day I addressed the Darjiling Terai planters at the Bordubi Club, and was then motored by the chairman, Mr. W. Y. Wyndham, to his house at Punkabari, where I had worked in 1898. Thence we proceeded to Kurseong, about 5,000 feet up the hills, where I had lived in 1898, and to Darjiling, where we spent Sunday, the 16th January, as guests of the Club. Next day we returned to Jalpaiguri, and then I addressed the planters at Nagrakata Club on the 18th, and visited a number of plantations, especially Meenglas Estate, on the 20th, where ANOPHELES-control had been a failure, or at least very slightly successful for a number of years. I attributed this to the fact that as the country was flat and open the area dealt with (a circle of only half a mile radius) was not sufficient (or nearly sufficient) to exclude outside ANOPHELES MACULATUS from entering the cooly lines, some of which were close to the boundary. In fact, a number of both larvæ and adults were caught fairly close by the same day, and the country is intersected with small nullas suitable for them. Also I doubted whether pipe drainage is not too expensive for such small ravines, which, one would think, might easily be kept trained and oiled at little annual cost.

Thence we took train on the 20th to Amingaon on the Brahmaputra, and then the river steamer to near Jorhat in Assam, which we reached on the evening of Sunday, the 23rd January, and where I addressed a large meeting of planters on arrival. We stayed with Dr. P. H. Carpenter, head of the Tocklai Tea-Experimental Station, a fine set of laboratories containing several departments devoted to scientific investigations in connection with tea-planting, and spent two days in discussing malaria-control with planters' doctors and in inspecting the Station. On the 25th evening we started by train from Jorhat to Silchar in lower Assam (Cachar), which we reached at 7 p.m. I was at once taken to the house of Dr. G. C. Ramsay and Mrs. Ramsay, fourteen miles away, where I saw next day the careful investigations which were being made by a number of workers under Dr. Ramsay on details of malaria- and mosquito-prevalence on the Tarrapore Tea Estate and neighbourhood—some of the best work now being done. I returned to Silchar and lectured to about 250 people at the Club. Next day we discussed malaria with the planters' doctors, as usual, and

were given a lunch by Mr. A. Stuart, of the Indian Tea Association's Silchar branch, and then departed by train to Chandpore, and thence by river steamers to Goalundo, and finally reached Calcutta again on the evening of Sunday, the 29th January.

This time I stayed in Calcutta with Dr. C. A. Bentley, Director of the Public Health Service of Bengal, and Mrs. Bentley. Dr. Bentley is himself one of the most distinguished experts on malaria in India, and is organising work among the general population and the difficult areas of Bengal; but unfortunately I had no time to inspect the numerous problems with which he is called upon to deal. On the 31st January and the 1st February I delivered two lectures on malaria at the Medical College to the staff, the students, and others, Colonel Megaw in the chair; and on the latter date at 5 p.m. received a civic welcome with a very kind address from the Mayor and Corporation of Calcutta at the Town Hall. On the 2nd February I attended a meeting of the Indian Tea Association in Calcutta, consisting largely of the owners of estates, and reported to them the conclusions we had formed from my tour and the proposals we had to make. I was also given a dinner by my old colleagues of the Indian Medical Service, Colonel Perry, P.M.O., in the chair, himself also one of the most distinguished students of malaria; and next day, the 3rd, after a lunch by Dr. and Mrs. Bentley, took the train to Bombay, where I embarked for home. We landed at Plymouth on the 24th February.

During my visits to Calcutta and after my return to England, I was consulted by the Eastern Bengal Railway regarding the extensive anti-malaria work which it proposes to undertake in the areas controlled by it. The schemes had been already approved by the Calcutta School of Tropical Medicine.

VI. CONCLUSIONS.

1. Comparing my own experiences when I served in India from 1881 to 1899 with my observations during the last two years in Ceylon, Malaya, Assam, and Calcutta, I conclude that there must be a marked reduction of Culicine mosquitoes in the houses of Europeans, due principally to the knowledge regarding these insects and their breeding habits now possessed by most of the householders and partly to the activities of local public health departments. But as the Culicines carry two important and still wide-spread diseases in India, namely, dengue and elephantiasis, and may carry more, I strongly advocate that all mosquitoes and not only ANOPHELES should be placed under still more close control by public action and should be put by health authorities in the same list as other disease-bearing vermin. Apart from disease, the annoyance caused by mosquitoes in general is great; and the cost of banishing them is small compared with the benefits of doing so.

2. Malaria-control in Malaya has reached a high state of efficiency and, unless it is neglected in the future for any cause, will quite possibly succeed (as Sir Malcolm Watson informed me) in practically banishing the disease or at least in reducing the pandemic to small local outbreaks. The various species of carrying ANOPHELES have been closely studied during a number of years, and the methods of control carefully tested—though it is hoped that future researches may still help us in these respects; effective legislation against breeding them has been passed; numerous local malaria-control boards have been established; and above all the authorities and all classes of the people recognise the benefits conferred by malaria-control and are anxious to have it extended as far as possible.

3. In Burma, so far as I could judge from enquiries made during my short visit to Rangoon, advance has not been nearly so rapid as in Malaya. This I judge to be due chiefly to the facts that the planting community is not nearly so large and that there is much more popular, and therefore less instructed, control of the administration. I know that H.E. the Governor, Sir Harcourt Butler, and his public health departments and organisations, are desirous of much wider development of malaria-control; but grants for it are not too generous, and the people have not yet been sufficiently educated to understand the mischief caused by their malaria and the advisability of reducing it. I suggest that the authorities might seek advice from and follow the examples of Malaya, especially as to the legislation and the organisation and the methods required. It is curious that while an outbreak of plague, for example, would at once set every wheel of

administration into action to prevent it, malaria which causes an actually larger morbidity and mortality is left unresisted for years owing to the very familiarity with it which makes it so pernicious to the country.

4. In Assam, things are evidently in a state of transition. Many planters are very keen to control their malaria and their ANOPHELES, but whatever they do are very apt to suffer from the indifference of their neighbours, whether these are other planters or are native villages close to their estates. The actual details of malaria-control for a large number of estates in Assam and the Duars have now been worked out and put on paper by Professor Strickland and others, but it is time that the whole movement should be unified in order to prevent expensive local failures due to recalcitrant neighbours and other causes. We therefore adopt the suggestion made to us by one of the planters' doctors that local malaria-control boards (on the model of the Malayan boards) should be set up for each group of plantations, as convenient, in order to obtain this unification. The boards should consist of managers, medical officers and other gentlemen interested in the work, and should have power to obtain expert advice, to draw up plans and schemes, to appeal for help to local authorities, especially in regard to defective conditions in neighbouring civil and railway areas, and if necessary to seek assistance, authorisation, or even legislation from governments. It would be useless to particularise further at this stage, but I think that government would be quite justified in insisting on the formation of such boards in view of the large amount of malaria now being acquired among the labour forces of many of the estates. Of course, the plantations must subscribe towards the expenses of the boards; but the costs are sure to be ultimately recouped by savings effected in the large expenditure now due to the disease—like the costs of every good sanitary measure everywhere; and I hope that governments will subscribe and if necessary legislate. What is wanted in Assam is not the will to move but the proper organisation. Another point is that the costs of sanitary improvements appear often to be largely taken from managers' allowances: if this is the rule—and I write under correction—it must be an effective bar to sanitary progress.

5. In Calcutta, general mosquito-control is, I am told, not nearly effective enough—though I myself did not see many mosquitoes there (as in 1898-9). As I said to the Municipality on the 1st February last, it does not spend enough money on this item of public health work, though dengue is prevalent every year and malaria still haunts the outskirts of the city. Calcutta has much to learn from Singapore. The housing of the poorest classes is also very evidently bad (see page 12), and I venture to make an earnest appeal for its improvement by legislation and action. Why the Indian people are still allowed to live in some areas like, let us say, Andamanese savages in the jungle, passes my comprehension. The bazaars are still dreadful, and I could see little improvement since my experiences

of thirty years ago. " Better houses, better health, more happy people, and more wealth " is a motto often forgotten, but the fundamental one for all cities. If as much attention were given to it as to many kinds of political and sectional propaganda the world would be a better one. The gospel of good health should be the first one for all nations—not the last, as now too often it is.

6. Nothing gave me greater pleasure during my tour than to hear of the formation and the work of the Co-operative Anti-Malaria and Public Health Societies of Bengal, managed by the people themselves, with many branches in remote villages and rural areas. This is the way towards effective control of those terrible pests which destroy so many of the dumb millions who live (and die) in those wide tracts. Nothing of the kind would even have been dreamed of in India thirty years ago, when medical men were generally met with opposition if not with hostility by the very people whom they were attempting to save. I was glad to hear that Lord Lytton had approved and assisted the scheme, and I should like to see it extended as much as possible throughout India. Rai Bahadur Dr. Gopal C. Chatterjee is to be warmly congratulated for his idea and for the work which he is doing in connection with it, and I can only regret that my time did not allow me to inspect some of his results, but hope I may be able to do so later. The late lamented Dr. Sir Kailas Chandra Bose, C.I.E., C.B.E., was head of the movement, but died while I was in the Duars.

7. Nearly thirty years have now elapsed since mosquitoes were proved to carry malaria. During that time many verifications of the mosquito-theory have been obtained, many details studied, especially in India, while not a few anti-malaria campaigns in the light of that theory have been conducted in various parts of the world. What can be done in other countries against malaria can be done in all. Where nothing is done great losses in health, money, and life continue to be inflicted on the suffering people. Is it not time to hope that malaria-control by modern methods will soon be adopted everywhere?

SIR RONALD ROSS'S VISIT TO MALAYA, ASSAM AND CALCUTTA, 1926-1927.

Itinerary.

Fri., 29th Oct., 1926.—Left Tilbury in P. & O. S.S. " Rajputana," 5 p.m.

Tues., 2nd Nov., 1926.—Arrived Gibraltar 7 a.m. Stayed with Colonel Langstaff, R.A.M.C.

Wed., 3rd Nov., 1926.—Called on Colonel Smales, D.S.O., R.A.M.C., M.O.H. of Gibraltar, at Municipal Offices.

Thurs., 4th Nov., 1926.—Visited slums at Gibraltar. Reception by the Municipality.

Sat., 6th Nov., 1926.—Inspected surrounding country with Colonel Smales.

Sun., 7th Nov., 1926.—Inspected Municipal Water-Works inside the Rock.

Mon., 8th Nov., 1926.—Sanitary consultation with Chairman of Municipality, the Hon. Mr. Bowring, and Colonel Smales. Dinner given to me by the Governor, H.E. Sir Charles Monro.

Wed., 10th Nov., 1926.—Left Gibraltar in P. & O. S.S. " Malwa " at noon.

Thurs., 11th Nov., 1926.—Wrote to Sir W. Simpson and Dr. Castellani on professional aspects of mosquito-control in Gibraltar. Discussed mosquito-control in Spain with the Count de Cartagena (formerly Spanish Ambassador in Russia), on board.

Sun., 28th Nov., 1926—Arrived Colombo 5 p.m.

Thurs., 2nd Dec., 1926.—Arrived Penang 8 p.m. Sir Malcolm Watson came on board to conduct me through Malaya.

Sat., 4th Dec., 1926—Arrived Singapore 2 p.m. We were met by the P.M.O., Hon. Dr. A. L. Hoops, the M.O.H., Dr. P. H. Hunter, and many other officers, and stayed with H.E. the Governor, Sir Laurence Guillemard. Visited the new General Hospital and dined with the Malayan Branch of the British Medical Association.

Sun., 5th Dec., 1926.—We inspected the municipal malaria-control work.

Mon., 6th Dec., 1926.—We inspected the malaria-control work at the projected new municipal waterworks for Singapore at Gunong Pulai. Lunched with the British Adviser to the Sultan of Johore.

Tues., 7th Dec., 1926.—We inspected rural mosquito-control work round Singapore with ten officers concerned. I lectured to about 500 people on malaria at the Medical College at 6 p.m.

Wed., 8th Dec., 1926.—We inspected malaria-control work at projected new Naval Base near Singapore with Surgeon-Commander Given, R.N., and the previous party. Embarked on S.S. " Ipoh " at 4 p.m. for Port Swettenham.

Thurs., 9th Dec., 1926.—Arrived Port Swettenham, 8.30 a.m., with Sir M. Watson. Inspected malaria-control work there and at Klang five miles away. Stayed with Sir M. and Lady Watson at Klang.

Fri., 10th Dec., 1926.—We drove thirty miles north of Klang inspecting malaria-control works in plantations, subsoil-water-pump, and Kapar Drainage Scheme.

Sat., 11th Dec., 1926.—We drove east many miles from Klang, inspecting similar work, especially at Bukit Kamuning Estate.

Mon., 13th Dec., 1926.—We inspected works at Kuala Lumpur, capital of the States, with a party of officers concerned. Also the Government Laboratories and Malaria Bureau. Lunch given by the medical men of Kuala Lumpur.

Tues., 14th Dec., 1926.—We inspected town near Jugra Hill which was formerly abandoned on account of malaria, and the new settlement. Also Morib, a sea-side resort, now healthy.

Wed., 15th Dec., 1926.—By motor and boat to Carey Island at the mouth of the Klang river, now rendered entirely free from malaria. Lady Watson's At Home.

Thurs., 16th Dec., 1926.—We inspected Seafield and other estates.

Sat., 18th Dec., 1926.—Kuala Lumpur again. Institute of Medical Research under Dr. W. Fletcher. Mosquito-proofed hospital on estate. Lunched with the Chief Secretary (Hon. W. Peel), and At Home by Mr. Choo Kia Peng, M.F.C.

Sun., 19th Dec., 1926.—1 p.m. we left Klang for motor-car tour north to Penang. Through Kuala Lumpur to Tanjong Malim Rest House. Inspected estates and children *en route*.

Mon., 20th Dec., 1927.—We stayed with Colonel and Mrs. Cecil Rae at Ipoh, after several interesting visits.

Tues., 21st Dec., 1926.—Visited Gopang Tin Mines. Luncheon at Batu Gajaha with 25 residents.

Wed., 22nd Dec., 1926.—Motored to Kuala Kangsar and to Kaiping. Called on Sultan of Perak and lunched with Mr. and Mrs. N. K. Bain, and stayed night with the British resident, Hon. H. W. and Mrs. Thomson, at Perak. Dined with the S.M.O., Dr. F. E. Woods, and others, at the Residency.

Thurs., 23rd Dec., 1927.—We motored to Penang via Krian (extensive paddy fields without malaria). Stayed hotel and dined at Club with the medical men of Penang, Dr. Gossip in the chair.

Fri., 24th Dec., 1927.—Breakfast by Dr. Smart and medical men at Swimming Club at Penang. Said farewell to Sir M. Watson, who returned to Klang. Boarded S.S. " Ellora " at 9.30 p.m. for Calcutta.

Mon., 27th Dec., 1926.—Arrived Rangoon 9 a.m. Went ashore to stay with B. Stephenson, Esq., Director of the Imperial Bank of India.

Tues., 28th Dec., 1926.—Interviews at the Government Offices and School of Hygiene with Colonel Bissett, I.M.S., the P.M.O., and with Major C. C. Jolly regarding malaria-control in Burma and several difficult cases.

Wed., 29th Dec., 1926.—Interviews continued. Called on the Minister of Health. Dinner by Sir Guy Rutledge.

Fri., 31st Dec., 1926.—Taken back to " Ellora " by Dr. Dalal, Port Health Officer, and friends. Evening, left for Calcutta.

Mon., 3rd Jan., 1927.—Arrived Calcutta noon. Met by Colonel J. W. D. Megaw, C.I.E., I.M.S., and Prof. C. Strickland, of the School of Tropical Medicine, Calcutta; by Dr. and Mrs. C. Bentley, head of the Public Health Service, Bengal; and by a deputation from 1,087 Indian Anti-malaria Societies. Stayed with Colonel and Mrs. Megaw.

Tues., 4th Jan., 1927.—School of Tropical Medicine and official visits and letters.

Wed., 5th Jan., 1927—Dined with the Governor of Bengal, H.E. Earl of Lytton, and Countess Lytton.

Thurs., 6th Jan., 1927.—Interviews with medical men. Lunched with Colonel F. A. F. Bernardo, I.M.S., head of the Calcutta Medical College.

Fri., 7th Jan., 1927.—" Gate of Commemoration " at my old laboratory at the Calcutta General Hospital, opposite the Victoria Memorial, opened by H.E. the Earl of Lytton, 5 p.m. Speeches, and large audience.

Mon., 10th Jan., 1927.—Lectured on malaria to Lord and Lady Lytton and a large audience, 6 p.m.

Tues, 11th Jan., 1927.—Public reception and presentation of address with a bag of 550 rupees for the Ross Institute, and a silver and gold casket, by the Indian Anti-malaria Societies, before a very large audience. At 7.30 p.m. left Calcutta with Prof. C. Strickland for tour in Duars, Terai, and Assam.

Wed., 12th Jan., 1927.—Jalpaiguri. Conference with twelve planters' doctors and lecture to a large meeting of planters. Complimentary lunch and dinner.

Thurs., 13th Jan., 1927.—Siliguri and Terai. Another lecture to planters. Stayed with W. Y. Wyndham, Esq., and Mrs. Wyndham at Punkarbari, where I worked on malaria in 1898.

Sat., 15th Jan., 1927.—Kurseong and Darjiling, where I worked in 1898. Guest of the Darjiling Club.

Mon., 17th Jan., 1927.—Returned Jalpaiguri. Stayed with Mr. and Mrs. Townend, I.C.S.

Tues., 18th Jan., 1927.—Addressed meeting of planters at Nagrakata, Duars. Guest of Dr. and Mrs. J. Phillips.

Wed., 19th Jan., 1927.—Visited several plantations in Duars. Hospitality from Dr. A. McCutcheon and Mr. and Mrs. Ducat.

Thurs., 20th Jan., 1927.—Visited Meenglas Estate, where malaria-control had not been a success, with the officials concerned. Area dealt with evidently too small. Evening, train to Amingaon on Brahmaputra river.

Fri., 21st Jan., 1927.—Arrived 8.30 a.m. and took river steamer " Duffla " up the river.

Sun., 23rd Jan., 1927.—Arrived Kokilamuth and Jorhat, evening. Stayed with Dr. P. H. Carpenter, head of the Tocklai Tea Experimental Station. Addressed meeting of planters at Jorhat Club.

Mon., 24th Jan., 1927.—Conference with planters' doctors.

Tues., 25th Jan., 1927.—Inspected the excellent Tocklai Experimental Station. Evening, train to Mariani and Silchar.

Wed., 26th Jan., 1927.—Arrived Silchar 7 p.m. Stayed with Dr. and Mrs. G. C. Ramsay, Cachar.

Thurs., 27th Jan., 1927.—Inspected Dr. Ramsay's careful studies of malaria and mosquitoes. Evening, lectured to 250 people, especially planters, at Silchar Club, and dined with Colonel Marshall and the Surma Valley Light Horse Mess.

Fri., 28th Jan., 1927.—Conference with planters' doctors. Complimentary lunch given by Mr. A. Stuart, Indian Tea Association. Train for Chandpore 4 p.m.

Sat., 29th Jan., 1927.—By train, river and train to Calcutta. Arrived evening with Prof. Strickland. Stayed with Dr. and Mrs. Bentley at Calcutta.

Mon., 31st Jan., 1927.—Lectured on malaria to about 400 doctors and students for the Calcutta School of Tropical Medicine.

Tues., 1st Feb., 1927.—Second lecture to complete the subject. At 5 p.m. received an official welcome from the Calcutta Corporation at the Town Hall with presentation of an address and a silver salver.

Wed., 2nd Feb., 1927.—Addressed meeting of Indian Tea Association, Calcutta. Was given a dinner by my old service, the Indian Medical Service, Colonel Perry, I.M.S., P.M.O. (himself a distinguished student of malaria), in the chair.

Thurs., 3rd Feb., 1927.—Farewell luncheon by Dr. and Mrs. Bentley. Took train for Bombay 8 p.m.

Sat., 5th Feb., 1927.—Embarked on P. & O. S.S. "Razmak." Mr. H. B. Clayton, I.C.S., Commissioner of Bombay Municipality, and others visited me on board. Left for home 1.15 p.m.

Mon., 21st Feb., 1927.—Met by Colonel Smales at Gibraltar.

Thurs., 24th Feb., 1927—Arrived Plymouth and London 5 p.m.

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